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ABSTRACT

A study investigated the role of phonemic information in young readers' silent reading comprehension. Subjects, 56 children in grades 2 and 4, from Seattle parochial schools, were blocked into groups based on their grade and skill level (skilled and less skilled). Each subject saw 48 sentences presented in a random order on an Apple II microcomputer. Each child was instructed to teach "Howie the Robot" to talk correctly. As a sentence appeared on the screen the child was to respond with a "yes" if the sentence made sense or a "no" if the sentence was silly or wrong. Results showed that a visual tongue twister effect (VTTE), similar to that found in adult studies, was observed in both second and fourth grade readers at two skill levels. This supports the view that phonemic information is used not only in word identification, but in text comprehension as well. Contrary to the initial hypotheses, it was found that neither skill level nor grade level interacted with this effect. Findings suggest that the VTTE taps a portion of the phonemic code that is not subject to substantial individual difference and/or develops quite early. (One figure and two tables of data are included.) (RAE)

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PHONEMIC SUPPORT IN CHILDREN'S COMPREHENSION

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ABSTRACT

This study investigated the role of phonemic information in young readers' silent reading comprehension. A visual tongue twister effect (VTTE), similar to that found in adult studies, was observed in both second and fourth grade readers at two skill levels. This supports the view that phonemic information is used not only in word identification, but in text comprehension as well. Contrary to the initial hypothesis, it was found that neither skill level nor grade level interacted with this effect. The conclusion is drawn that the VTTE taps a portion of the phonemic code that is not subject to substantial individual difference and/or develops quite early. Further research is suggested to relate these findings to existing research which shows that good readers are more sensitive to phonemic information, as detected using words that rhyme, than are poor readers.

In 1967, Chall coined the phrase, "The Great Debate" to refer to a broad disagreement in the reading field between those who emphasized phonemic processes in word identification (decoding skills) and those who emphasized conceptual integration in comprehension. More recent research in the psychology of the reading process has helped us to understand that there is no strict boundary between these two skills, but rather that the two types of processes are related to each other and interact with one another as a person reads connected text. Many researchers would now agree that reading is an interactive process with influence flowing in both directions between low level decoding skills and high level comprehension skills (see for example Perfetti, 1985 and Stanovich, 1980). When we look for individual differences in reading ability, not surprisingly, we find that "good things go together", that is, good readers are better than poor readers both at the phonologically based word decoding skills and in top down comprehension skills. Thus the "Great Debate" between teaching decoding or teaching comprehension has become almost a moot point. Both skills are necessary and should presumably be addressed in a reading program.

Still, a greater understanding is needed of the processes underlying these two types of skills, in order to better understand the basis for individual differences in reading ability. What is the nature of the relationship between decoding and comprehension? How do these two types of processes interact with each other as a person reads? To what extent is phonological information used during text comprehension? These

are the question that originally motivated the research reported here. Thus we revisit the "Great Debate", not to try to prove that one skill is more or less important, but to try to understand how the two skills are related one to the other. Specifically, we investigate the role of phonological information (i.e. "the sounds of the words") in silent reading, hypothesizing that phonological information is important not only in decoding but in higher level text comprehension as well.

Research clearly shows that high skilled readers attend more to phonological information than do less skilled readers, at least when they read isolated words. Several types of research bear on this issue. (See Wagner & Torgesen, 1987, for a review of this literature). Speed of naming pseudowords (nonsense words which conform to English sound patterns, e.g. "lut") is a task that clearly differentiates good from poor readers (Perfetti & Hogaboam, 1975). This is usually interpreted to mean that unskilled readers have a disability in decoding, i.e. applying a rule-governed mapping from symbol to sound, rather than simply recognizing words visually (a strategy which is unavailable for pseudowords). A second type of research in this area involves the presentation of regular (e.g. "cut") and exception words ("put") for subjects to name (Baron & Strawson, 1976). Although good readers are faster than poor readers overall, if word frequency is controlled (Seidenberg, Waters, Barnes & Tanenhaus, 1984), good readers name exception words more slowly than regular words while poor readers show less of an effect of word type. This is taken as an indication that good readers are decoding

using sound based rules more than are poor readers. Since decoding is not an effective strategy for exception words, the reader who decodes will be slowed down when reading such words. It is hypothesized that poor readers are identifying both regular and exception words through a visual recognition strategy, therefore they identify regular and exception words at the same rate.

During reading acquisition, the visual route is not always available, however. Young readers must learn to "break the code" in order to read new words. It is estimated that at least twenty encounters with a new word are necessary before it is added to the child's sight word vocabulary (Ekwall & Shanker, 1988). Research confirms that comprehension suffers greatly in the absence of decoding skill. In their classic study, Perfetti & Hogaboam (1975) found that poor decoders are also poor comprehenders. They advance the explanation that poor readers expend so many resources (in particular, short term memory space) on low level decoding, that few resources are available for higher level text comprehension processes.

Once a word is decoded, a representation of that word must be saved in short term memory (STM) as the reader continues to build a meaning for the entire sentence. Perfetti and McCutchen (1982) propose a model of reading in which phonological information plays a significant role during the comprehension process. They call this role "Phonemic Support" and hypothesize that the function of phonological codes is to help differentiate

lexical items in STM during sentence processing. The evidence they provide is from the Visual Tongue Twister research reported in McCutchen & Perfetti (1982). In this series of experiments, it was shown that for skilled adult readers, sentences containing content words which repeated the same word-initial phoneme (tongue-twisters) took substantially longer to read than carefully matched control sentences. Their explanation of this phenomenon is that words with the same initial phoneme are confused with one another in short term memory, and that sentence comprehension is slowed since these confusions must be resolved before comprehension can take place. In Perfetti and McCutchen (1982), the hypothesis is advanced that lack of facility with phonemic information is causally implicated in the comprehension failures seen in less-skilled readers. Less-skilled readers are less able to hold on to lexical representations and their meanings in short term memory during text comprehension, since these lexical representations are not as effectively supported by phonemic codes.

A great deal of information regarding the nature of the phonemic code used in STM is provided by their study. The "repeated phoneme" was actually an abstract consonantal point of articulation, e.g. "t" and "d" were considered to be the same. Only word-initial consonants were manipulated in the studies, providing evidence that the initial consonant is quite salient, even though we know from linguistic research that it lacks acoustic duration. Finally, it was shown that the phoneme rather

than the grapheme (i.e. the written letter) was providing the interference, since varied spellings were used for the same sound. Thus, a word's representation in short term memory during sentence comprehension seems to tap a more abstract level of representation than just an acoustic echo or a visual image of the lexical item.

A simplified information processing diagram of the reading model suggested here is presented in Figure 1. Phonological information is part of the data which is passed from the low level lexical access (i.e. word identification) module to the higher level text comprehension module. We might ask what else besides phonological information is present in this code? Clearly, it is not just an acoustic image, but includes information gleaned from the visual characteristics of the word (Baron, 1973). In addition, the representation of the word must contain enough semantic information to allow comprehension to take place. Whether the representation is best modelled by an interactive network of activations or by a more serial information processing model is beyond the scope of this discussion. Still, within either of these models, the contents of the code used to represent a lexical item can be specified, and must include phonological as well as graphemic and semantic information.

Figure 1

Reading Process Model

Although a great deal of research has focussed on the use of phonological information in the reading of isolated words, little research has been done investigating the use of phonological codes in sentence processing by young readers. One of the few studies was carried out by Mann, Liberman, and Shankweiler in 1980. They examined the effect of phonological information in a sentence memory task. Sentence memory may tap some of the same skills as sentence comprehension, although the exact relationship is still to be determined. In this memory task, young readers were asked to repeat sentences, some of which contained rhymes such as "Lucy is free to see T.V. with Dee and Lee". Skilled second-graders were superior to unskilled second-graders only for those sentences which did not contain rhymes. In the rhyming condition, the performance of the two groups was equivalent. Thus, the skilled reader seems to have more sensitivity to a phonological representation in short term memory. This type of experiment also provides evidence that such sensitivity to phonological information is not within conscious control, since the good readers are unable to suppress the effect in situations where their performance is impaired.

In general, of course, we would claim that sensitivity to phonological information would improve rather than impair a reader's comprehension, by enabling better differentiation among lexical items being held in STM. The nature of this type of research involves the use of carefully constructed stimuli that disrupt normal processing in some way, so that researchers can

examine specific effects of different kinds of linguistic information on the complex comprehension process.

The goal of the present study was to further investigate the nature of the phonological code used during sentence comprehension from a developmental perspective. Our first research goal was to ascertain if young readers show a VTTE of the same kind found by McCutchen & Perfetti (1982). In addition, we wished to ascertain if there was a developmental aspect to the phenomenon, hypothesizing that the magnitude of the VTTE would increase with the age of the reader due to experience with and reliance on the phonological codes. Finally, based on the research of Mann et al. (1980), as well as the general findings in phonological sensitivity in word identification, we hypothesized that poor readers would show less of a Visual Tongue Twister Effect than would good readers of the same age.

Method

Subjects. Subjects were 56 children from Seattle parochial schools. These children were blocked into groups based on their grade and skill level. There were two skill groupings, (skilled and less skilled) based on teacher report and scores on the Stanford reading diagnostic test. Children who scored near the median were not selected for the study. None of the children were diagnosed as learning disabled or dyslexic. There were two grade groupings: second grade and fourth grade. The groups were

approximately balanced for sex, although sex was not a controlled variable. In addition, there were two blocks of stimuli so that each subject only saw 48 of the 96 total sentences. The stimuli block variable was counter-balanced with respect to subjects and thus not considered in the analysis.

Materials. Each subject saw 48 sentences, presented in a random order on an Apple II microcomputer. These 48 sentences were constructed as 8 sets of 6 sentences each. They were created using words of relatively high frequency in third-grade reading material (from norms provided in Carroll, Davies & Richman, 1971). Each sentence set was based on one syntactic pattern, or frame, with only content words free to vary. For example, one syntactic frame might be NOUN + VERB + ADJECTIVE + NOUN. The content words were chosen on the basis of word initial consonant. Two types of tongue twisters, those repeating "t/d" and those repeating "s/z" were contrasted with control sentences within each sentence set. In addition, the control sentence was a semantic paraphrase of one of the tongue twisters in the set. Since the task involved verification of sentence acceptability, three of the sentences within each set were grossly ungrammatical and/or semantically unacceptable. Meaningless sentences were created by shuffling content words which had been used in the acceptable sentences, but shuffled across all sets of sentences. A sample sentence set in presented in Table 1.

Table 1

Sample Sentence Set

Through the use of the syntactic frame approach, our goal was to control for syntactic complexity. By creating control sentences which were semantically parallel to one of the two yoked tongue-twisters, our goal was to control for semantic complexity. The variable of word frequency was also rigidly controlled within each sentence set, since the tongue-twisters had a mean word frequency equal to or slightly higher than the matched control sentence. Since we know that grammatical structure, semantic complexity and word frequency affect reading times, controlling for these variables would allow us to more confidently attribute any observed differences to the phonemic content of the sentences.

Procedure. Each child was tested individually, with each session lasting approximately 20 minutes. The children were told that their task was to teach "Howie the Robot" to talk correctly. They were to read each sentence as quickly as possible and press a button on the keyboard labelled YES if the sentence made sense. If the sentence was "silly" or "wrong" they were to press the button labelled NO. Several practice sentences were given to the children and when they said they were ready the 48 experimental sentences were presented one by one on the screen. Sentences

stayed on the screen until the child pressed the YES or NO button, and after the child responded, the next sentence appeared in 750 msecs. The computer recorded error and response time data.

Results

Error rates and reading times were each analyzed using analysis of variance (ANOVA). The design was factorial, with sentence type treated as a repeated measure. Subjects were nested within the two blocking variables of Grade (2 & 4) and Skill (High & Low) and crossed with Sentence Acceptability (Yes & No) and Phoneme Type (Alveolar Stop, Alveolar Fricative, & Control). See Table 2 for a summary of the findings.

Table 2

Experimental Findings

In both the error rate and reading time ANOVA, significant main effects of grade and skill were found as expected. Fourth graders made fewer errors, $F(1,52) = 8.85$, $p < .01$, and read the sentences more quickly, $F(1,52) = 10.11$, $p < .01$, than did second graders. The fourth graders had a group mean error rate of 1.018 (max = 8 in all cases), and a group mean response time of 6531.86 msecs. The second graders had a group mean error rate of 1.601 and a group mean response time of 8320.83 msecs. High skilled readers made fewer errors, $F(1,52) = 20.19$, $p < .01$, and

read the sentences more quickly, $F(1,52) = 17.95$, $p < .01$, than did less skilled readers. The high skilled readers had a group mean error rate of .869 and a group mean response time of 6234.82 msecs. The low skilled readers had a group mean error rate of 1.750 and a group mean response time of 8617.86 msecs.

There was a significant effect of acceptability, although the effect went in different directions in error rate and reading time. Meaningless sentences took longer to read than did acceptable sentences. The mean response times were 7232.36 msecs for acceptable and 7620.31 msecs for meaningless sentences, $F(1,52) = 8.31$, $p < .01$. Meaningless sentences produced significantly fewer errors, however, than did acceptable sentences, $F(1,52) = 19.92$, $p < .01$. Compare the mean error rate of 1.714 for acceptable sentences to the mean error rate of 0.905 for unacceptable sentences. It was apparently easier for the children to decide that a sentence was meaningless than it was for the children to decide that a sentence was meaningful. It does not seem far-fetched to conclude that slightly different processing is involved in trying to read meaningless sentences. This has no particular bearing on our theoretical question however.

A robust Tongue Twister Effect (i.e., main effect of phoneme) was found, comparable to that seen in adult studies. This effect was reflected strongly in the reading time, $F(2, 104) = 19.06$, $p < .01$, but not in error rate, $F(2, 104) = 1.16$,

$p > .05$. The mean response times were 7763.82 msecs, 7443.44 msecs, and 7071.76 msecs for s, t, and control sentences respectively. The mean error rates were 1.191, 1.291, and 1.336 again for s, t and control sentences respectively. Note that very few errors were made, particularly by high skilled readers in both grades (cell means less than 1.0, max = 8). This indicates that the children had no trouble with the task itself, and could distinguish easily between meaningful and meaninglesss sentences, regardless of phonological content. Planned orthogonal comparisons were done on the reading time data, using Bonferroni's inequality to determine the appropriate critical value for the test of significance. Since two comparisons were done, for $p < .05$ per experiment, the critical value for each comparison is $p < .025$. The contrast between Tongue Twisters and Controls was significant, $F (1, 104) = 29.96$, $p < .025$, and accounted for 78.6% of the variance reflected in the main effect of phoneme. The contrast between "s" tongue twister and "t" tongue twister was also significant, $F (1, 104) = 8.15$, $p < .025$, however.

Contrary to our hypothesis, there were no significant interactions between Phoneme Type and Skill nor between Phoneme Type and Grade. All children seemed to be affected similarly by the phonemic confusability of the tongue twisters.

Discussion

The results of this experiment suggest that phonological information is present in short term memory during sentence comprehension in young readers. This effect is clearly reflected in response times for both acceptable and unacceptable sentences, although not in error rates. Use of a sentence verification paradigm has allowed an examination of phonemic processes at work during actual reading, adding to data from studies involving sentence memory and the reading of isolated words. Our findings clearly show that children, like adults, are sensitive to the sounds of words, even when reading silently, and that the sounds of the words from an entire sentence interact when reading connected text. This lends further confirmation to the view that phonological information is important, not only during lexical decoding, but during text comprehension as well.

An unexpected, but quite interesting finding of this study is the lack of interaction between either grade level or skill level with the VTTE. Apparently, the Visual Tongue Twister Effect is tapping a phonological process which is fundamental to the reading process and not subject to substantial individual differences, or developmental differences. Another possibility is that the phonological process tapped in our experiment develops very early and reaches asymptote before second grade. This can only be determined by further research with even younger readers.

How can these findings be reconciled with those of Mann et al. (1980), in which rhyming did influence sentence memory differentially according to skill level, with higher skilled readers being more sensitive to rhymes? It seems that two types of explanations are possible and only further research can determine whether either or perhaps both explanations are valid. The first explanation would claim that the tasks are substantially different, tapping different skills, and thus the results are not comparable, since in the Mann et al. study, memory for sentences was the experimental task, rather than sentence comprehension. The second explanation rests on the different types of phonological information manipulated in the two experiments. In Mann et al., rhymes were examined. Many studies have shown that good and poor readers are differentially affected by rhymes during the decoding process, e.g. Byrne & Shea (1979). Perhaps the first consonant of the word has a different status from fuller phonological representations containing vocalic information allowing for the detection of rhymes.

Let us pursue this second explanation for a moment. The results we have obtained suggest that the first consonant of the word is perhaps a "lowest common denominator" of phonological information used in the STM representation of a lexical item. Sensitivity to the first consonant is not reflective of individual differences in ability, representing in some sense a floor of phonological activation. We might speculate that good readers are able to enrich this code with additional information.

Most of the research that has shown individual differences between good and poor readers used rhyming paradigms rather than tongue twisters. Perhaps good readers use an enhanced phonological code, which is a fuller phonological image of the word, thus making them more susceptible to confusions due to rhyme.

Perfetti and McCutchen (1982) hypothesize that insensitivity to phonemic information is causally related to the comprehension problems experienced by less-skilled readers. Less-skilled readers, being less facile than skilled readers with phonemic codes, work with impoverished lexical representations in STM, resulting in confusions and comprehension failures. This claim is not directly supported by the results obtained here, since no differences were found between good and poor readers. Further research is needed to ascertain if differences do exist in the phonological representations used by good and poor readers, with poor readers using an impoverished representation as Perfetti and McCutchen suggest.

Several research studies are suggested to clarify further the exact characteristics of the phonological code used in short term memory during sentence comprehension. First, a rhyming experiment needs to be done in which not just sentence memory is measured, but comprehension time (using response latency) so that comparisons can be made with the consonantal VTTE. This experiment should use the same subject groupings as the present

study so that comparisons can be made. In such a study, we would look for skill differences in sensitivity to rhyme, hypothesizing that good readers would show more of an effect due to their enriched phonological representations. Second, a more fine-grained look at the nature of the phonological code needs to be undertaken. What parts are obligatory and what parts are "elaborations"? Do we find phonemes in stressed syllables more salient than those in unstressed syllables, providing further evidence for "speech processes" at work in silent reading? Finally, what is the nature of the distinction between consonant and vowel? Will we find for example that initial phoneme or initial consonant is the more important piece of the phonological code?

In conclusion, what are the educational implications of this line of research? We have provided further evidence that phonological information is vital not only to decoding but to comprehension. Children need to learn to attend to the sounds of the words in order to read and comprehend. In the past, a "Phonics" approach, early in reading instruction, has been shown to be effective in teaching children to attend to phonological information. Our research suggests that phonics may be especially appropriate when used in conjunction with an approach that emphasizes comprehension as well. More importantly, however, this research has shed light on some of the processes that underly reading and perhaps individual differences in reading ability. If we can understand in a more detailed way how

STM codes differ between good and poor young readers, we will be much further along the way toward early detection of problems, and the development of specific effective remediation techniques.

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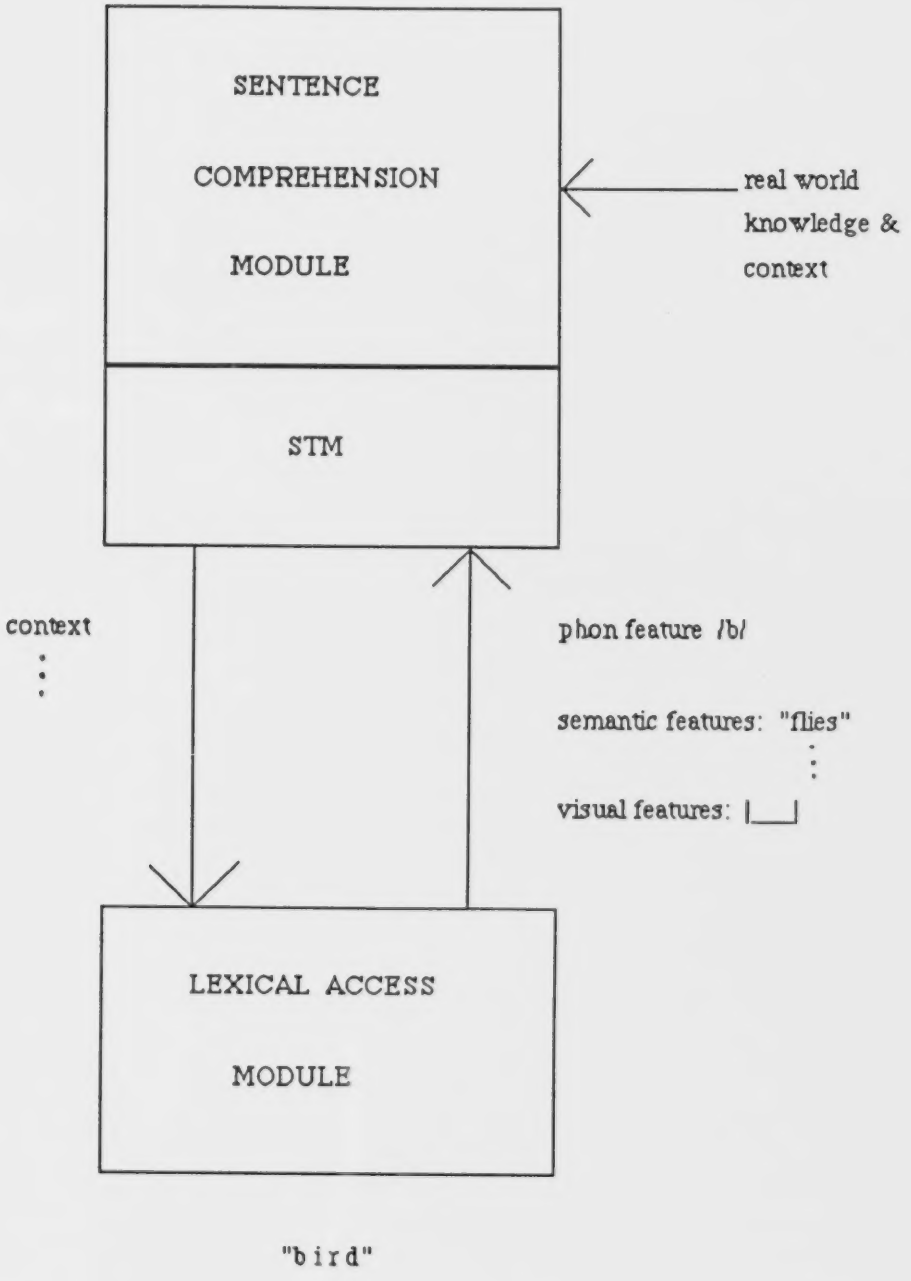

FIGURE 1: READING PROCESS MODEL

GRAMMATICAL SENTENCES (S, T, Control)

1. The stack of sticky sandwiches smelled sweet.
2. Dozens of the dried tomatoes tasted terrible.
3. The crate of unusual vegetables appeared rotten.

UNGRAMMATICAL SENTENCES (S, T, Control)

1. The soup of salty sum seemed scattered.
2. Two of the twisted teapots travelled true.
3. The crate of gray jokes raced mountain.

Table 1: A Sentence Set

	Reading Times in Secs (Errors)		
	S	T	Control
2nd Grade			
Skilled	7.756 (0.929)	7.435 (0.929)	7.104 (1.071)
Less Skilled	9.513 (2.107)	9.354 (2.143)	8.763 (2.429)
4th Grade			
Skilled	5.194 (0.643)	5.127 (0.893)	4.793 (0.750)
Less Skilled	8.592 (1.143)	7.857 (1.429)	7.627 (1.250)

The effects of grade, skill, and phoneme were all significant at the level of $p < .01$. The effect of acceptability was also significant at the $p < .01$ level, although it is not broken out in the table, since it has no particular bearing on our hypothesis. There were no significant interactions. See text for exact values of F.

Table 2: Experimental Findings